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NATIONAL DAM SAFETY PROGRAM. HENPECK HOLLOW DAM (MO 31256), MIS--ETC(U)

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# PHASE I INSPECTION REPORT

## NATIONAL DAM SAFETY

Henpeck Hollow Dam (MO 31256),  
Mississippi - Kaskaskia - St. Louis Basin,  
Washington County, Missouri. Phase I  
Inspection Report.

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9 Final rept.,

10 Stanley F. /Gizienski  
Jean-Yves /Perez

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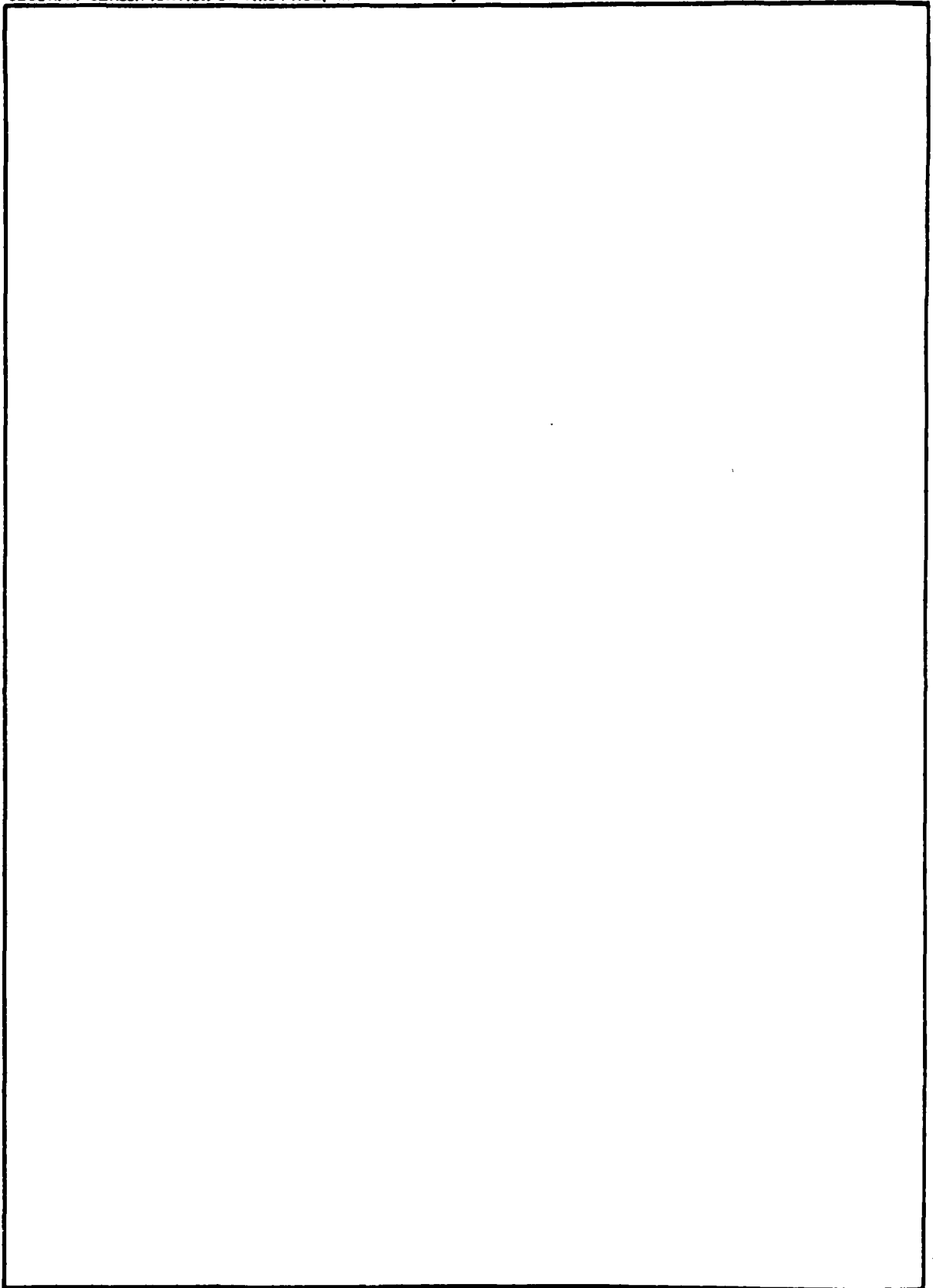
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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ST. LOUIS DISTRICT, CORPS OF ENGINEERS  
210 TUCKER BOULEVARD, NORTH  
ST. LOUIS, MISSOURI 63101

REF ID:  
ATTENTION OF

SUBJECT: Henpeck Hollow Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Henpeck Hollow Dam (MO 31256).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

SUBMITTED BY:

Chief, Engineering Division

3 MAR 1981  
Date

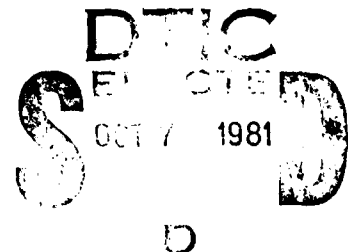
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**HENPECK HOLLOW DAM**  
Washington County, Missouri  
Missouri Inventory No. 31256

**Phase I Inspection Report**  
**National Dam Safety Program**

Prepared by

**Woodward-Clyde Consultants**  
Chicago, Illinois

Under Direction of  
St Louis District, Corps of Engineers

for  
Governor of Missouri  
December 1980

## **PREFACE**

*This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.*

*In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.*

*It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.*

PHASE I REPORT  
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Henpeck Hollow Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of Courtois Creek
Date of Inspection	7 August 1980

Henpeck Hollow Dam, Missouri Inventory No. 31256, was inspected by S. F. Gizienski (geotechnical engineer), R. Juyal (hydrologist) and J. B. Stevens (geotechnical engineer).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to provide for an expeditious identification based on available data and a visual inspection, of those dams which may pose hazards to human life and property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers (SLD), has classified this dam as having a high hazard potential; we concur with this classification. The estimated damage zone length, as determined by the SLD, extends approximately four miles downstream of the dam. Within this estimated damage zone are a dam and reservoir (MO 31255), several dwellings and miscellaneous buildings.

The dam is classified as small due to its approximately 60 ac-ft storage volume. The dam is approximately 24 ft in height. The small dam classification includes dams between 25 and 40 ft in height, or having storage volumes between 50 and 1000 ac-ft.

Based on the distances to the nearest occupied dwellings, over 2.5 miles, the width of the valley downstream of the dam, on the order of 400 feet or more, and the relatively small impoundment volume, 50 percent of the PMF is recommended as the spillway design flood.

Our inspection and evaluation indicate the dam is in a generally poor condition. Primary reasons for this judgement are: the inadequate spillway capacity, the passage of discharge from the auxiliary spillway over the downstream slope, partial blockage of the main spillway by a beaver dam, lack of maintenance and lack of periodic inspections.

Our hydrologic/hydraulic studies indicate that a 1 percent probability-of-occurrence event (100 year flood) will not result in overtopping of the dam. The 1 percent probability-of-occurrence event is equivalent to a storm which has 1 chance in 100 of occurring any one year; that is, a storm which occurs on the average once every 100 years. These analyses also indicate that the dam will be overtopped for a hydrologic event which produces greater than 21 percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The following specific remedial measures and additional studies are recommended for the Henpeck Hollow Dam:

1. Design and construction of spillway(s) with adequate capacity to pass at least 50 percent of the PMF without endangering the dam with passage of discharge flows over or near the downstream slope. The spillway(s) should be protected to prevent erosion.
2. Determination of the cause of the "dip" or depression observed in the dam crest.
3. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.
4. Evaluation of available options for an effective and practical warning system to alert downstream residents, should potentially hazardous conditions develop at the dam.
5. Implementation of an inspection and maintenance program for the dam and appurtenant structures. Records of the inspections and maintenance should be kept. This program should include but not be limited to the following:

- a. Inspection of the embankment to identify any signs of slope instability such as slumping, cracking or deformation;
- b. Monitoring the wet area near the dam toe to determine if the quantity of seepage is increasing or if the seepage water is becoming turbid.
- c. Inspection of the spillways and downstream channels for evidence of blockage by beaver activity or serious erosion during flood flows.
- d. Maintenance should include removal of brush and small trees from the dam crest, slopes and spillway channels. Removal of trees from the embankment should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing of trees could jeopardize the safety of the dam.

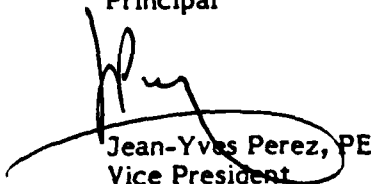
The analyses and implementation of all remedial measures should be performed by an engineer experienced in the design and construction of earth dams.

It is recommended the owner take action on the recommendations concerning spillway improvements without undue delay to preclude deterioration which could lead to the development of hazardous conditions at this facility. Recommendations 2, 3, 4 and 5 should be addressed and implemented as soon as practical.

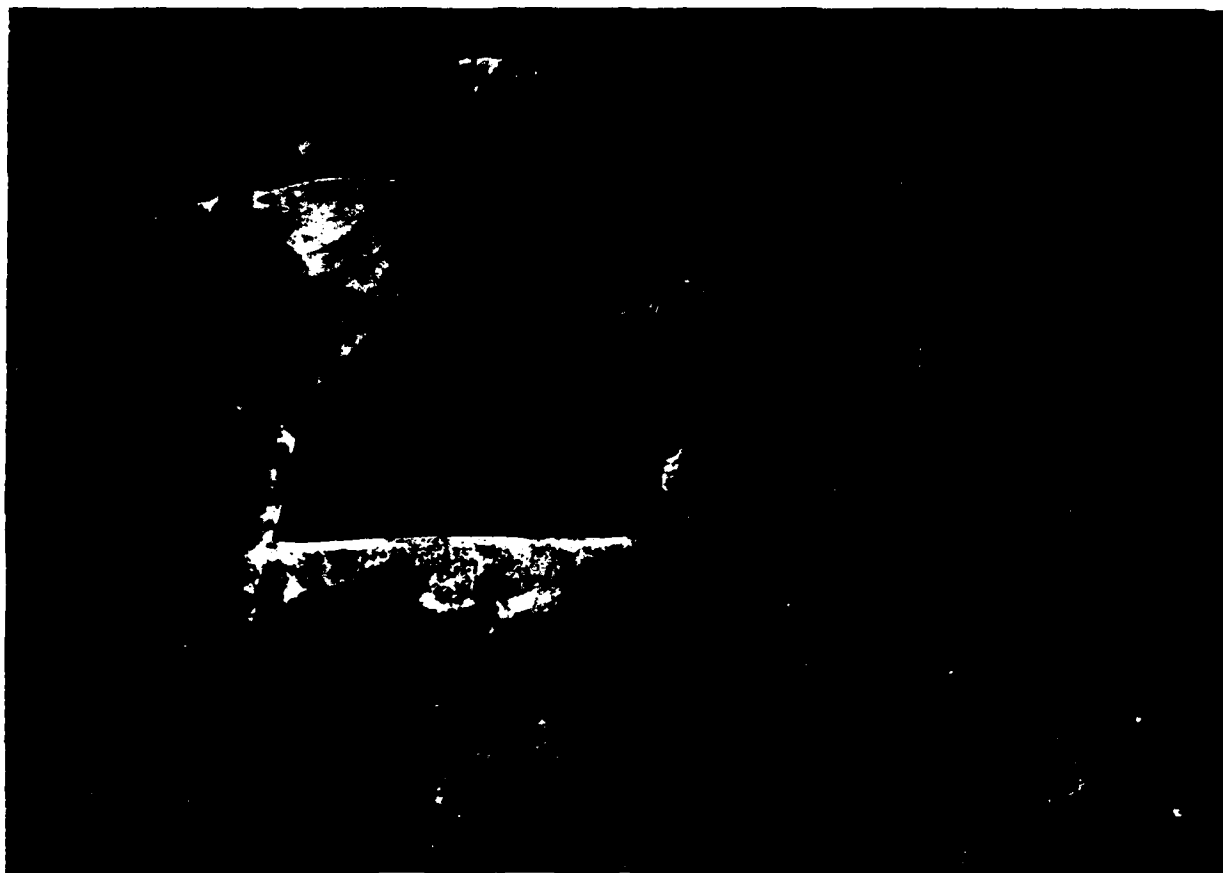
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Stanley F. Gizienski, PE  
Principal



Jean-Yves Perez, PE  
Vice President



OVERVIEW

HENPECK HOLLOW DAM

MISSOURI INVENTORY NO. 31256

PHASE I INSPECTION REPORT  
NATIONAL DAM SAFETY PROGRAM  
HENPECK HOLLOW DAM, MISSOURI INVENTORY NO. 31256  
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1. Site Location Map
2. Drainage Basin and Site Topography
3. Plan and Section of Dam and Sections of Main and Auxiliary Spillways
4. Regional Geologic Map

## APPENDICES

### A Figure A-1: Photo Location Sketch

#### Photographs

1. View along dam crest from right abutment. Main spillway in foreground.
2. Upstream slope from south side of reservoir. Observers standing at dip in dam profile. Note gravel wave protection.
3. Downstream slope from right abutment.
4. Discharge channel from main spillway, looking upstream. Soil is moderately erodible.
5. Beaver dam at entrance of main spillway.
6. Deterioration of spillway lining. Note undercutting and large cobbles for energy dissipation.
7. Entrance of auxiliary spillway at left abutment.

### B Hydraulic/Hydrologic Data and Analyses

**PHASE I INSPECTION REPORT**  
**NATIONAL DAM SAFETY PROGRAM**  
**HENPECK HOLLOW DAM, MISSOURI INVENTORY NO. 31256**

**SECTION I**  
**PROJECT INFORMATION**

**1.1 General**

- a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Henpeck Hollow Dam, Missouri Inventory Number 31256.
- b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations, and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").
- c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

## 1.2 Description of Project

- a. Description of dam and appurtenances. Henpeck Hollow Dam is an earth dam constructed to form a recreational lake. An uncontrolled, brick and mortar-lined spillway is located at the north end of the dam (right abutment). An auxiliary spillway, located at the south end (left abutment), is also uncontrolled and earth-lined. There are no low-level outlets or pool regulating structures other than the spillways.
- b. Location. The dam is on an unnamed tributary of Courtois Creek about 4.4 mi north of Berryman, Missouri, in westernmost Washington County. It is located in Sec 25, T38N, R2W on the USGS Berryman 7.5-minute quadrangle map, (1978). It is about 0.5 mi north of a US Forest Service Road which is an extension of Missouri Highway W.
- c. Size classification. The dam is classified as small due to its approximately 60 ac-ft storage volume. The dam is 24 ft high. The small dam classification includes dams from 25 to 40 ft in height, or having storage capacities between 50 and 1000 ac-ft.
- d. Hazard classification. The St Louis District, Corps of Engineers (SLD), has classified this dam as having a high hazard potential; we concur with this classification. The damage zone length, as estimated by the SLD, extends approximately four miles downstream from the Henpeck Hollow Dam. A dam and reservoir (MO 31255), as well as several dwellings and miscellaneous buildings, are located within this estimated damage zone.
- e. Ownership. We understand the dam is owned by Mr Donald Gill, 2830 Melody Lane, St John, Missouri, 63114. Correspondence should be addressed to his attention.
- f. Purpose. The impoundment is used for recreational purposes.
- g. Design and construction history. According to Mr Gill, the dam was constructed during the winter of 1975-76. There was no engineered design. It was constructed by Mr Cecil Hedrick of Steeleville, Missouri but no construction records were kept.

- h. Normal operating procedures. No operating records or procedures were found. Maximum pool elevation is controlled by the elevation of the main spillway crest.

### 1.3 Pertinent Data

- a. Drainage area. 0.48 mi<sup>2</sup>
- b. Discharge at damsite (ft<sup>3</sup>/sec).
- |   |              |
|---|--------------|
| Maximum known flood at damsite                      | Not observed |
| Warm water outlet at pool elevation                 | N/A          |
| Diversion tunnel low pool outlet at pool elevation  | N/A          |
| Diversion tunnel outlet at pool elevation           | N/A          |
| Gated spillway capacity at pool elevation           | N/A          |
| Gated spillway capacity at maximum pool elevation   | N/A          |
| Ungated spillway capacity at maximum pool elevation | 460          |
| Total spillway capacity at maximum pool elevation   | 460          |
- c. Elevation (ft above MSL).
- |   |                  |
|---|------------------|
| Top of dam                                | 1008.8 to 1010.5 |
| Maximum pool-design surcharge             | N/A              |
| Full flood control pool                   | N/A              |
| Recreation pool                           | 1005.1           |
| Spillway crest (gated)                    | N/A              |
| Upstream portal invert diversion tunnel   | N/A              |
| Downstream portal invert diversion tunnel | N/A              |
| Streambed at toe of dam                   | 986.7            |
| Maximum tailwater                         | Unknown          |
- d. Reservoir.
- |                              |         |
|------------------------------|---------|
| Length of maximum pool       | 1600 ft |
| Length of recreation pool    | 1550 ft |
| Length of flood control pool | N/A     |

e. Storage (acre-feet).

Recreation pool	33
Flood control pool	N/A
Design surcharge	N/A
Top of dam	60

f. Reservoir surface (acres).

Top of dam	8
Maximum pool	8
Flood-control pool	N/A
Recreation pool	6
Spillway crest	6

g. Dam.

Type	Earth
Length	403 ft
Height	24 ft
Top width	10 ft
Side slopes	Downstream 3(H) to 1(V); Upstream $\pm 2.8$ (H) to 1(V) on exposed portion
Zoning	Unknown (probably homogeneous)
Impervious core	Unknown (probably none)
Cutoff	Unknown (probably shallow trench)
Grout curtain	Unknown (probably none)

h. Diversion and regulating tunnel.

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating Facilities	N/A

i. 1. Main spillway

Type	Concrete and brick-lined, uncontrolled, trapezoidal, broad-crested weir (5 ft wide)
Length of weir	12 ft
Crest elevation	1005.1 ft
Gates	None
Upstream channel	None
Downstream channel	Unlined earth

2. Auxiliary spillway

Type	Unlined soil, uncontrolled, roughly trapezoidal
Length of weir	Approximately 18 ft at bottom
Crest elevation	1007.1 ft
Gates	None
Upstream channel	None
Downstream channel	Unlined earth

j. Regulating outlets. None

## SECTION 2 ENGINEERING DATA

### 2.1 Design

No design plans or reports were found for Henpeck Hollow Dam.

### 2.2 Construction

No construction records or data were found.

### 2.3 Operation

There are no records of outflow at the spillway or of the history of the pool elevations.

### 2.4 Evaluation

- a. Availability. The only engineering data obtained for this report was developed during the field inspection. No engineering design data or construction reports were found for this dam.
- b. Adequacy. Insufficient data were available to determine the adequacy of the design.

Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be conducted by an engineer experienced in the design and construction of dams.

- c. Validity. Not applicable.

## 2.5 Project Geology

The Henpeck Hollow Dam site is located on the north flank of the Ozark structural dome. The regional dip in the area is to the northwest. Bedrock in the area is mapped on the Missouri Geologic Map (1979) as Ordovician age Gasconade Formation (Fig 4). The Gasconade Formation is typically a light brownish-gray cherty dolomite, with a basal sandstone, the Gunter member. Caves and springs are common in the Gasconade; however no evidence of solution activity was noted at or near the dam site during the visual inspection.

The soil at the dam site is typically a tan to light reddish brown, gravelly to clayey silt, and silty clay (ML-CL). It appears to be a residual soil developed on the weathered Gasconade Formation. The soil is mapped on the Missouri General Soil Map (1979) as Captina-Clarksville-Doniphan Association.

A small, (2 mi long) fault is mapped 2.5 miles east of the dam, and a longer (16 mi), fault is mapped about 5 mi west-northwest of the site. The faults are within Paleozoic formations and are likely of Paleozoic age. These faults are not in a seismically active area and are not considered to pose a significant hazard to the dam.

### SECTION 3 VISUAL INSPECTION

#### 3.1 Findings

- a. **General.** A visual inspection was made of Henpeck Hollow Dam on 7 August 1980 without the owner's representative present. The results of the inspection indicate the dam is in generally poor condition.
- b. **Dam.** The dam was constructed with a moderately plastic gravelly, tan, silty clay (CL) obtained from the reservoir area. The gravel portion of the soil is an angular chert up to cobble size. The clay appears to be a silty residual soil developed by weathering of the dolomite bedrock.

The slopes and crest of the dam have a thick grass cover with scattered small bushes. There is no riprap on the upstream slope. In the vicinity of the high-water mark, the fine-grained portion of the soil has been washed away and only the gravel remains. This gravel provides some wave protection. Above the high-water mark the slope is covered with grass (see Photo 2; Appendix A). Further limited wave erosion is expected on the upstream slope but it is not presently endangering the safety of the dam.

The horizontal alignment of the dam does not appear to have been disturbed. About 320 ft from the main spillway is a dip or depression of about 1.5 ft in the dam profile. Close examination did not reveal the cause. There is no evidence of sinkhole development, cracking, or slides. It does not appear to be the result of settlement. It is possibly the result of the lax construction control.

No animal burrows were observed in the dam. There were many signs of beaver activity in the reservoir area including a dam constructed near the entrance of the main spillway (see Photo 5; Appendix A).

No seepage was noted on the downstream slope of the dam. There is a depressed wet and spongy area about 50 ft in diameter located 30 ft below the

toe of the dam (Fig A-1) which appears to be the result of seepage. No estimate of the seepage rate could be made, as there was no flow at the time of our inspection.

c. Appurtenant structures.

1. Main spillway. The main spillway, located at the right (north) abutment, is an ungated, trapezoidal channel with a brick and mortar weir, approximately 12 ft long and about 5 ft wide (Fig 3). The brick and mortar did not appear to be reinforced. Set into the mortar are large cobbles (Photos 1 and 6) which are intended to provide energy dissipation. At the downstream end, an 18 in. drop has been eroded and undercuts the weir (Photo 6). Near the main spillway entrance, beavers have constructed a small dam.

2. Auxiliary spillway. The auxiliary spillway is constructed in unlined earth at the left (south) abutment. It is uncontrolled and roughly trapezoidal in shape. The auxiliary spillway is approximately 18 ft wide (Fig 3).

d. Reservoir. The reservoir is used for recreational purposes. Slopes in the area are wooded and relatively flat. No signs of slope instability were observed. As the drainage area is heavily wooded with very little development, very little sediment is transported into the lake.

e. Downstream channel. The downstream channel from the main spillway has been cut into the in-situ soil. It is approximately trapezoidal in shape and about 6 ft wide at the bottom. The soil has moderate to high erosion potential. Discharge in this channel is carried well away from the toe of the dam.

From the auxiliary spillway, the discharge passes through an ill-defined, uncleared channel. At least a portion of the flow passes along the southern, dam-abutment contact. Erosion is likely to occur in this area during heavy discharge through the auxiliary spillway. At the dam toe, the discharge enters the natural stream channel.

### 3.2 Evaluation

Our visual inspection did not find any sinkhole development, slides, cracking, or other evidence of instability. The low spot on the dam crest may be the result of settlement, or the dam may have been constructed that way. The cause could not be determined during the inspection.

Although no animal burrows were seen, there was considerable beaver activity noted in the reservoir area. This included the dam constructed by beavers near the main spillway entrance. The beaver dam reduces the main spillway capacity.

At the main spillway, deterioration by erosion threatens the mortar and brick lining. Continued backward erosion at the downstream end is likely to cause eventual loss of the lining. Erosion will also continue to deepen the downstream discharge channel but this is not expected to endanger the dam as the channel is not near the toe of the compacted dam embankment.

The passage of auxiliary spillway discharge along the dam-abutment contact at the south end of the dam could potentially cause serious erosion and possible failure of the dam.

The wet area near the toe indicates that limited seepage under the dam is taking place. The volume of seepage at the time of inspection did not appear significant from the point of view of dam safety.

## SECTION 4 OPERATIONAL PROCEDURES

### 4.1 Procedures

So far as could be determined there are no written operational procedures for this dam. The water level is controlled by the crest of the main spillway.

### 4.2 Maintenance of Dam

No records of maintenance on this facility were available.

### 4.3 Maintenance of Operating Facilities

There are no facilities requiring operation at this dam.

### 4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this facility.

### 4.5 Evaluation

There are apparently no maintenance or operational procedures in effect. The lack of regular maintenance and periodic inspection is considered a deficiency.

The feasibility of a practical and effective warning system should be evaluated to alert downstream residents, should potentially hazardous conditions develop during periods of heavy precipitation.

## SECTION 5

### HYDRAULIC/HYDROLOGIC

#### 5.1 Evaluation of Features

- a. Design data. No hydrologic or hydraulic information was available for evaluation of the dam. Pertinent dimensions of the dam and reservoir were surveyed on 8 August 1980, measured during the field inspection or estimated from topographic mapping. The map used in the analysis was the USGS Berryman, Missouri, 7.5-minute quadrangle map, (1978).
- b. Experience data. No recorded rainfall, runoff, discharge, overtopping or pool stage historical data were available for this reservoir or watershed.
- c. Visual observation. At the time of inspection, there was no evidence of past overtopping. There is a beaver dam near the main spillway entrance which should be removed as it obstructs outflow. It was assumed in the analysis that this beaver dam will be washed away for any significant flood flow. Further construction of dams by beavers in the spillway areas could seriously reduce spillway capacity. Other observations regarding the spillways and downstream channels are given in Section 3.
- d. Overtopping potential. Hydrologic and hydraulic analyses indicate the dam will not be overtopped by the 1 percent probability-of-occurrence event (100 year flood). These analyses also indicate the spillway can pass only 21 percent of the Probable Maximum Flood (PMF) without overtopping the embankment. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The following table presents the expected severity of overtopping for various storm events:

Percent PMF	Maximum Water Surface Elevation, ft (MSL)	Maximum Depth Over Dam, ft	Maximum Outflow, ft <sup>3</sup> /sec	Duration of Overtopping, hrs
21	1008.8	0	460	0
50	1009.9	1.1	1170	4.0
100	1010.7	1.9	2350	6.3

The input data and output summaries for these analyses are presented in Appendix B. Copies of the complete analyses are available in our project files.

The well developed grass cover on the dam crest and downstream slope, and the gravelly clay soil comprising the embankment indicate the dam is moderately resistant to erosion. As the main spillway is concrete lined and the auxiliary spillway is unlined earth, erosion will occur in the auxiliary spillway for flow velocities of greater than 5 ft/sec. This occurs for outflows greater than 460 ft<sup>3</sup>/sec. Overtopping of a considerable depth and duration, such as has been calculated for 50 and 100 percent of the PMF, could cause sufficient erosion to pose a hazard of failure to this dam.

Based on the distance to the nearest occupied dwellings, over 2.5 miles, the width of the valley downstream of the dam, approximately 400 ft, and the small impoundment volume, 50 percent of the PMF is recommended as the spillway design flood. This design flood should be treated in such a way that the entire spillway design flood could pass without flowing over or near the compacted earth embankment.

## SECTION 6 STRUCTURAL STABILITY

### 6.1 Evaluation of Structural Stability

- a. Visual inspection. The visual inspection of the Henpeck Hollow Dam revealed no evidence of horizontal displacement of the dam crest alignment. A dip or depression in the vertical profile did not appear to be the result of slope instability but, rather the result of lax construction control. Cracking, detrimental settlement, slides, undue deformation or other signs of instability were not observed. No seepage on the downstream slope or at the toe was observed. However, there was a wet area beyond the dam toe which appears to be the result of limited seepage.

The gravelly, silty clay soil used to construct the dam is not considered as having a high liquefaction potential.

- b. Design and construction data. No design or construction data were available for this dam and spillway. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available.
- c. Operating records. No operating records or water level records are maintained for this facility.
- d. Post construction changes. The lack of drawings or construction reports precludes the identification of post construction changes. However, there were no obvious changes observed.
- e. Seismic stability. The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. In view of the gravelly clay used in the construction of the dam, liquefaction is considered unlikely during a moderate seismic event. However, since soil property data and static stability analysis is not available for review, the seismic stability cannot be properly evaluated.

## SECTION 7 ASSESSMENT/REMEDIAL MEASURES

### 7.1 Dam Assessment

- a. **Safety.** Based on the visual inspection, the Henpeck Hollow Dam is judged to be in generally poor condition. The primary reasons for this judgment are: the inadequate spillway capacity, the passage of flow from the auxiliary spillway over the downstream slope, partial blockage of the main spillway by a beaver dam, lack of maintenance, and lack of periodic inspections. Seepage and stability analyses comparable to the recommended guidelines were not available, which is also considered a deficiency.

- b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the conclusions and recommendations in this Phase I report.

The lack of stability and seepage analyses as recommended in the guidelines preclude an evaluation of the structural and seismic stability of the dam. This is considered a deficiency.

- c. **Urgency.** The deficiencies described in this report could affect the risk of failure of this dam. It is suggested that the recommendations presented in Section 7.2b be implemented to prevent the development of hazardous conditions. Action concerning spillway improvements should be taken without undue delay. The remaining recommendations should be acted on as soon as practical.

- d. **Necessity for Phase II.** In accordance with the Recommended Guidelines for Safety Inspection of Dams, the subject investigation was a minimum study. This study revealed that additional in-depth investigations as described in Sec 7.2b are needed to complete the assessment of the safety of the dam. It is our understanding from discussions with the St Louis District that these additional in-depth investigations are the responsibility of the owner.

## 7.2 Remedial Measures

- a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these general options are:
  1. Remove the dam, or breach it to prevent the storage of water.
  2. Increase the height of dam and/or spillway size to pass the spillway design flood without overtopping the dam.
  3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.
  4. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes the chances for loss of life).
- b. **Recommendations.** Based on the inspection of Henpeck Hollow Dam, it is recommended that further study be made to evaluate, as a minimum, the following:
  1. Design and construction of spillway(s) with adequate capacity to pass at least 50 percent of the PMF without endangering the dam with passage of discharge flows over or near the downstream slope. The spillway(s) should be protected to prevent erosion.
  2. Determine the cause of the "dip" or depression observed in the dam crest.
  3. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of earth dams.
  4. Evaluation of available options for an effective and practical warning system to alert downstream residents, should potentially hazardous conditions develop at the dam.

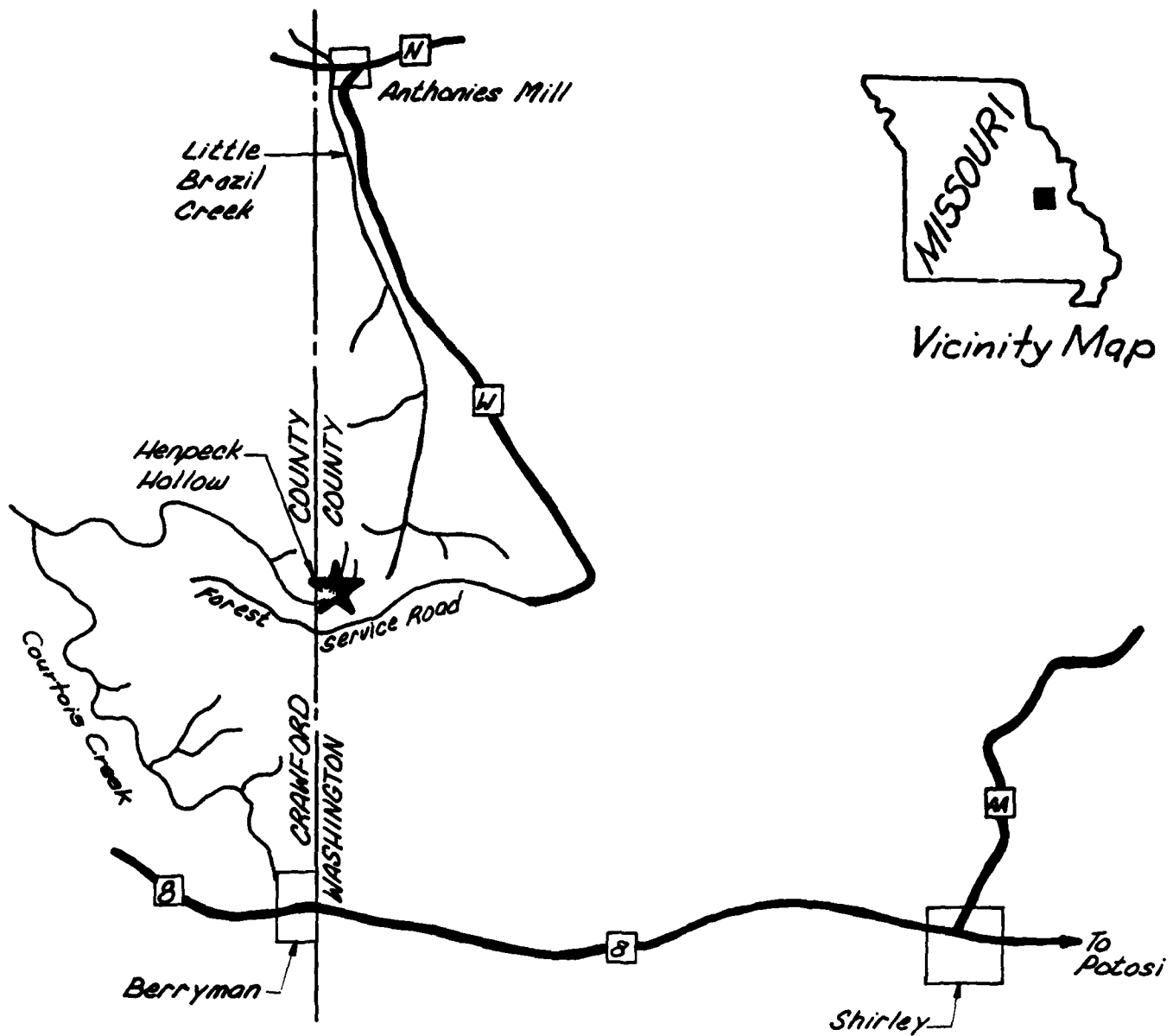
c. **O & M procedures.** A program of periodic inspections and maintenance should be implemented for the dam and appurtenant structures. This program should include but not be limited to the following:

1. Inspection of the embankment to identify any signs of slope instability such as slumping, cracking or deformation;
2. Monitoring the wet area near the dam toe to determine if the quantity of seepage is increasing or if the seepage water is becoming turbid;
3. Inspection of the spillways and downstream channels for evidence of blockage by beaver activity or serious erosion during flood flows;
4. Maintenance should include removal of brush and small trees from the dam crest, slopes and spillway channels. Removal of trees from the embankment should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing of trees could jeopardize the safety of the dam.

All maintenance and remedial measures should be performed under the guidance of an engineer experienced in the design and construction of dams. Records should be kept of recommended and performed maintenance or remedial construction.

## REFERENCES

- Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.
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- Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, "National Program of Inspection of Non-Federal Dams".
- Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".
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- Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.
- St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".
- US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.
- US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



### Legend

- County Line
- State highway and Route No.
- River or Creek
- City or Town
- Project location

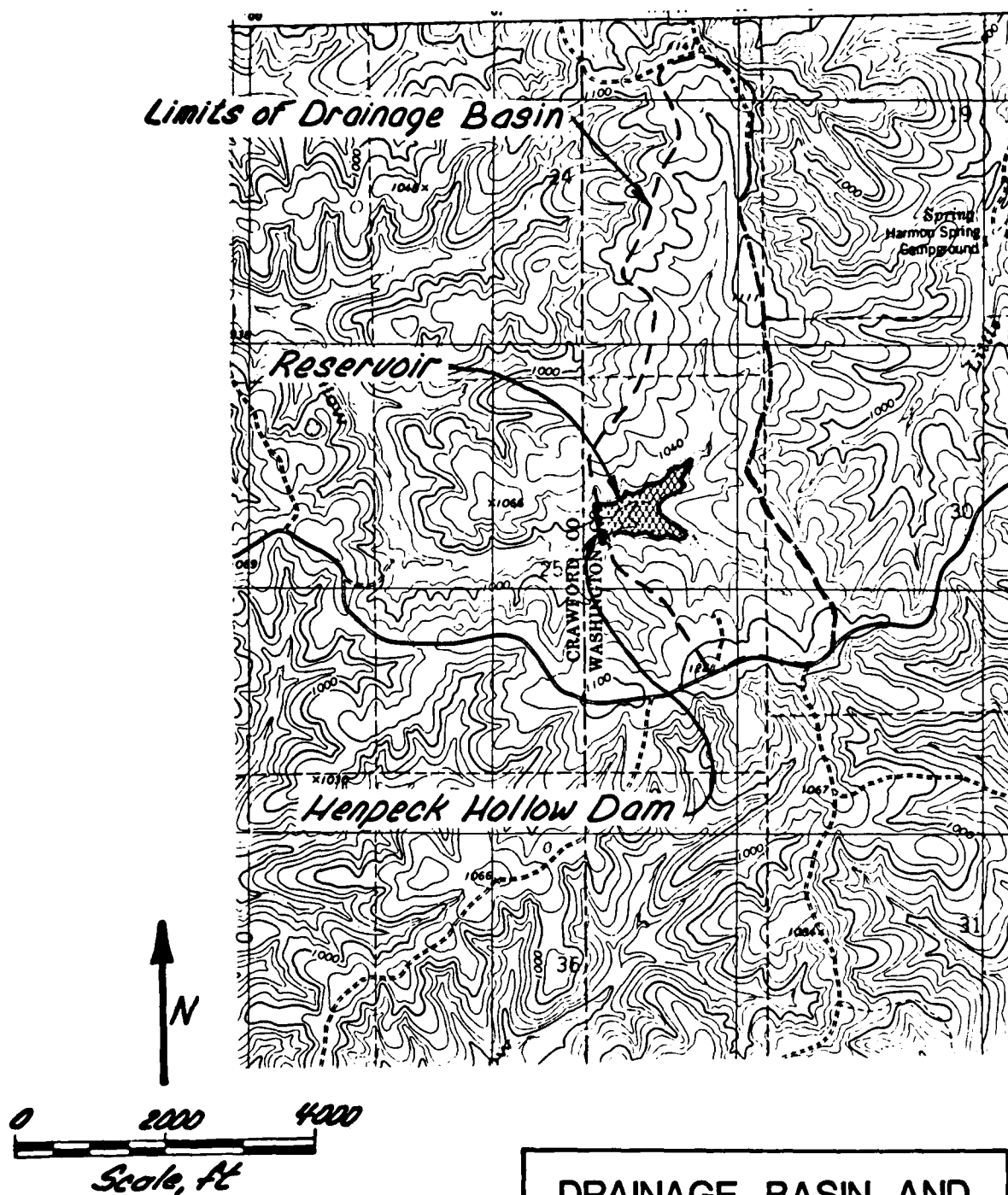


## SITE LOCATION MAP

HENPECK HOLLOW DAM

MO 31256

Fig. 1



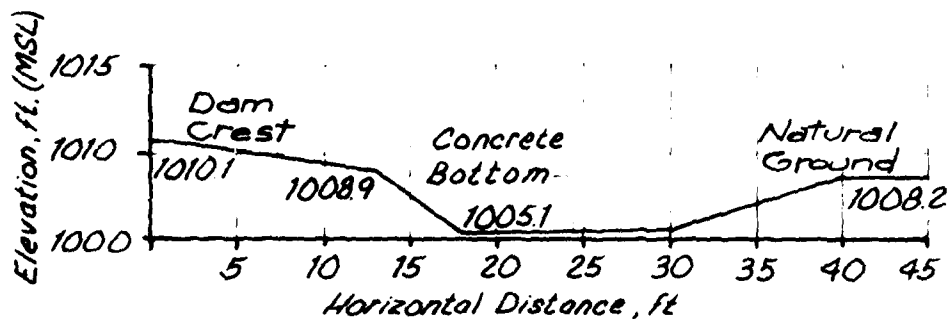
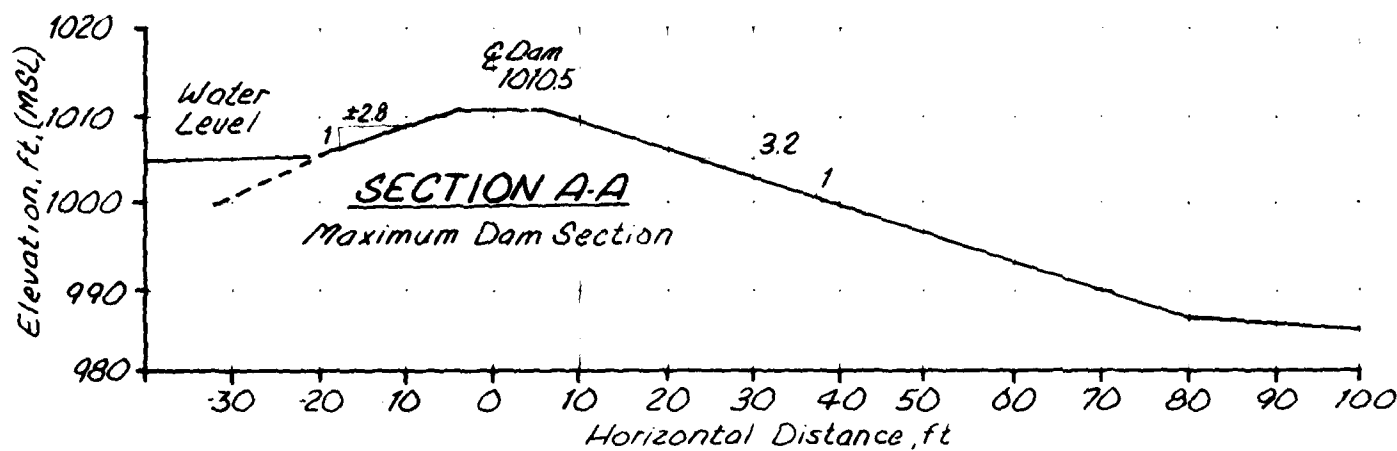
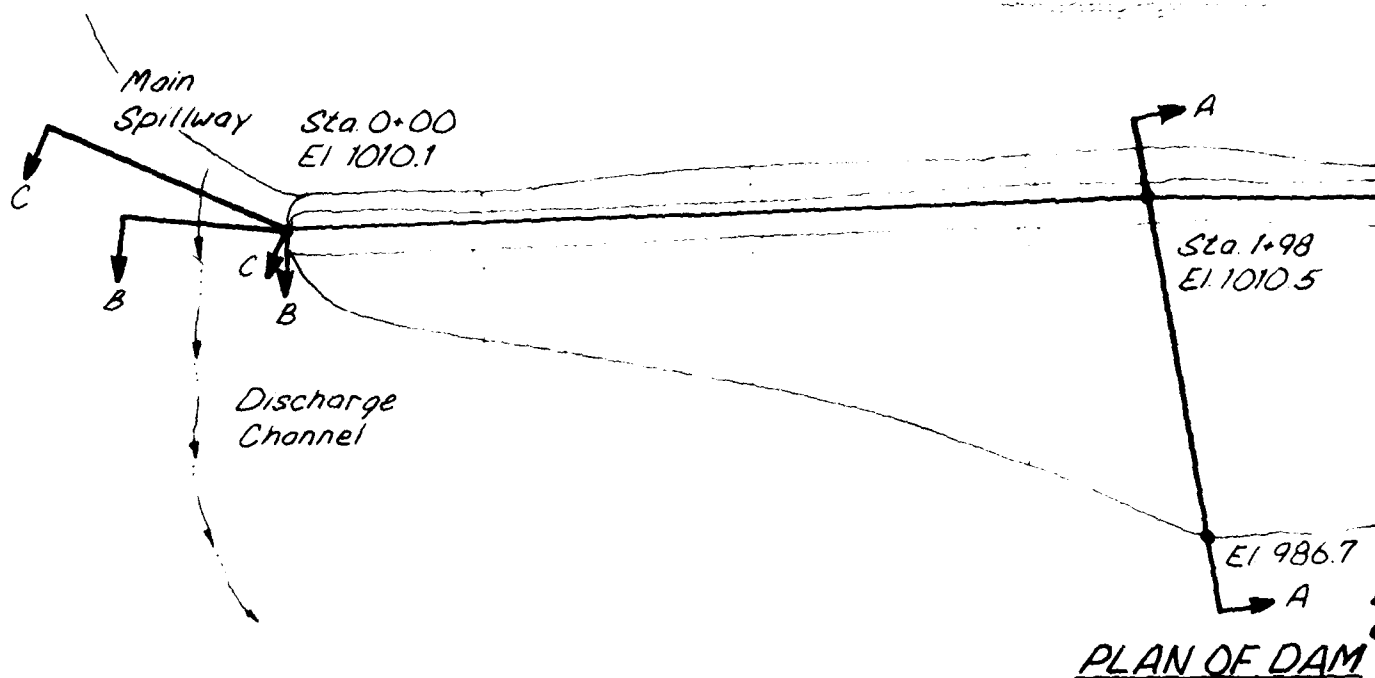
*1. Topography obtained  
from U.S.G.S. Barryman  
7½ minute quadrangle.*

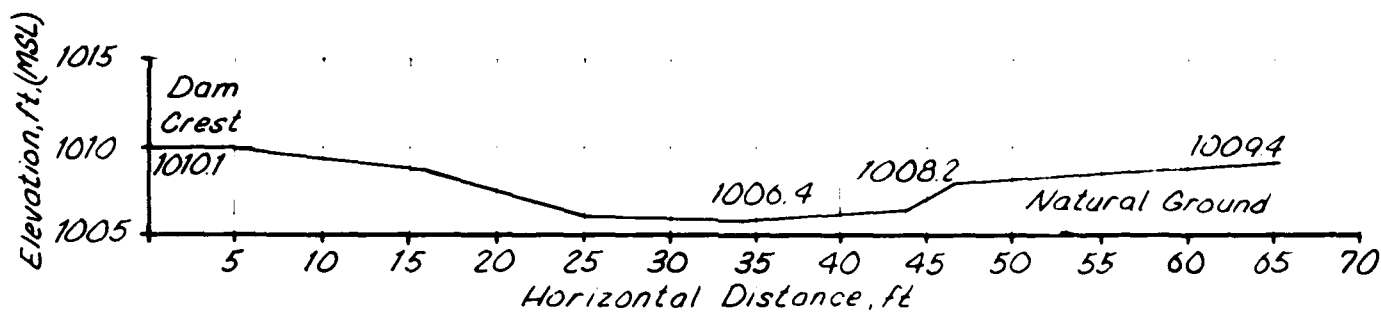
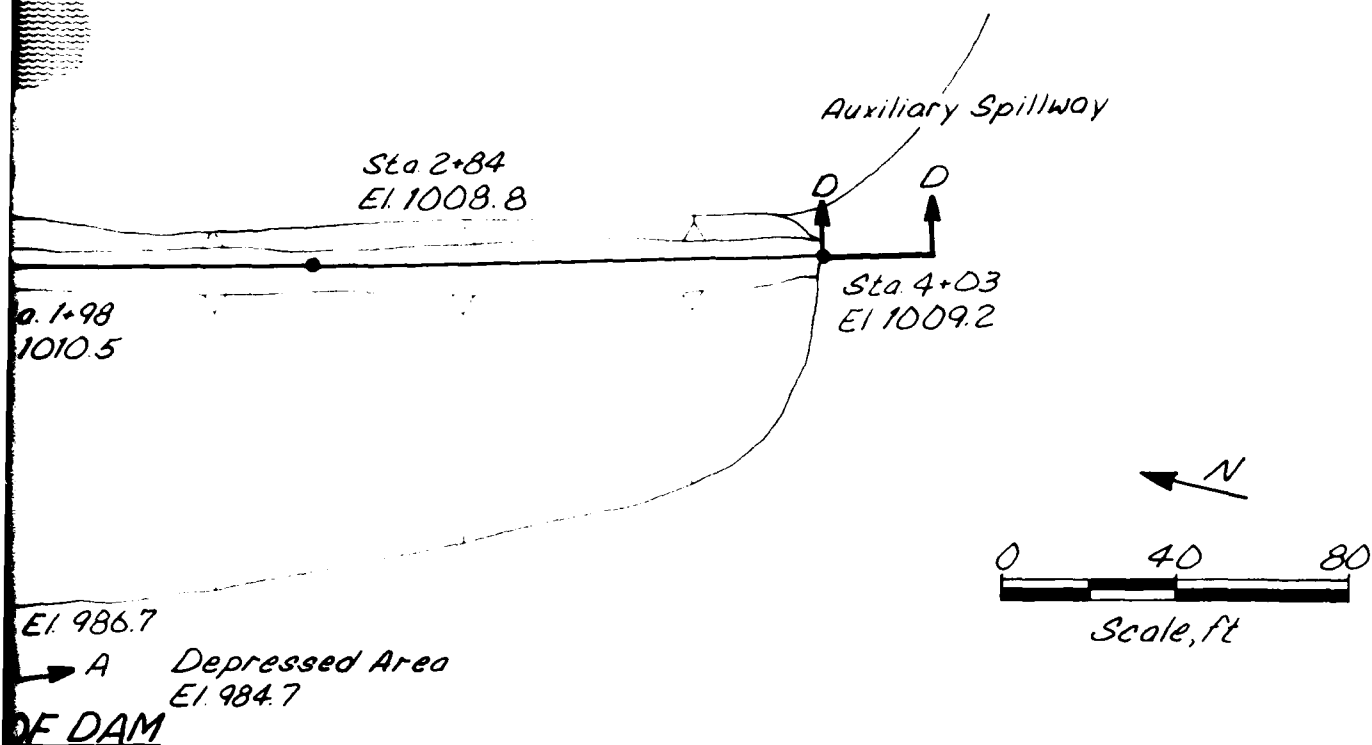
## DRAINAGE BASIN AND SITE TOPOGRAPHY

HENPECK HOLLOW DAM

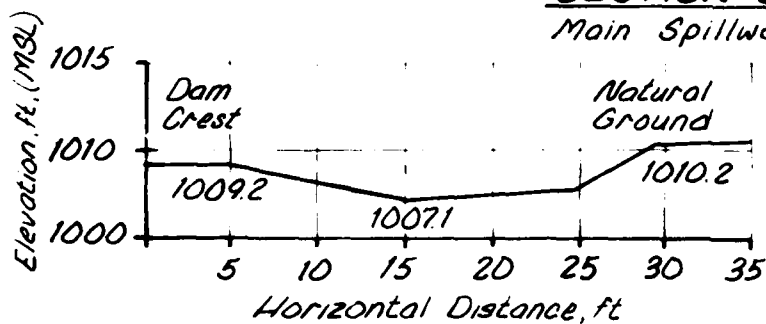
MO 31256

Fig. 2





**SECTION C-C**  
Main Spillway



**SECTION D-D**  
Auxiliary Spillway

**PLAN AND SECTION OF  
DAM AND SECTIONS OF  
MAIN AND AUXILIARY  
SPILLWAYS**

HENPECK HOLLOW DAM

MO. 31256

Fig. 3

# DAM LOCATION



## Legend



Roubidoux Formation



Gasconade Dolomite  
Gunter Sandstone Member



Eminence Dolomite



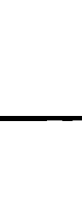
Potosi Dolomite



Derby-Doerun Dolomite



Davis Formation



Bonneterre Formation  
Whetstone Creek Member  
Sullivan Siltstone Member



Reagan Sandstone  
(subsurface, western Missouri)



Lamotte Sandstone



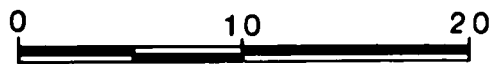
Diabase (dikes and sills)



St. Francois Mountains Intrusive Suite



St. Francois Mountains Volcanic Supergroup



Scale, mile

## REGIONAL GEOLOGIC MAP

HENPECK HOLLOW DAM

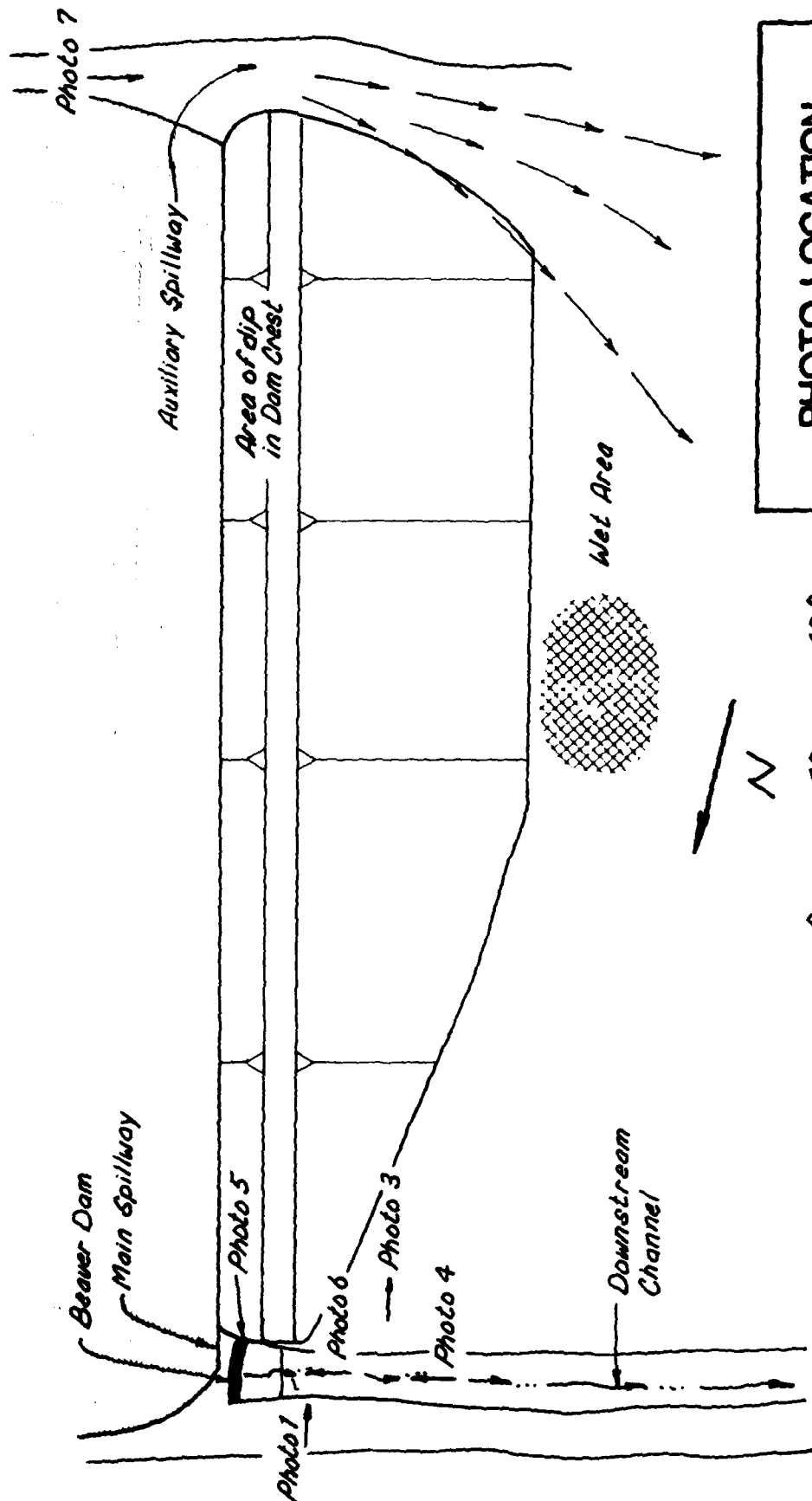
MO 31256

FIG 4

## **APPENDIX A**

### **Photographs**

Photo 2

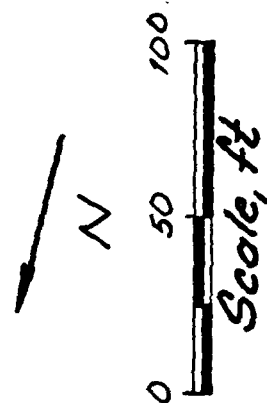


# PHOTO LOCATION SKETCH

HENPECK HOLLOW DAM

MO 31256

Fig. A1





1. View along dam crest from right abutment. Main spillway in foreground.



2. Upstream slope from south side of reservoir. Observers standing at dip in dam profile. Note gravel wave protection.



3. Downstream slope from right abutment.



4. Discharge channel from main spillway, looking upstream. Soil is moderately erodible



5. Beaver dam at entrance of main spillway.



6. Deterioration of spillway lining. Note undercutting and large cobbles for energy dissipation.



7. Entrance of auxiliary spillway at left abutment.

## **APPENDIX B**

### **Hydraulic/Hydrologic Data and Analyses**

## APPENDIX B

### Hydraulic/Hydrologic Data and Analyses

#### B.1 Procedures

- a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

Due to the presence of a beaver dam upstream of the spillway that is higher than the main spillway elevation, the beaver dam was assumed to be washed away for any significant outflow.

- b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).
- c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi<sup>2</sup>, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8} (s+1)^{0.7}}{1900 Y^{0.5}} \quad (\text{Equation 15-4})$$

where:  $L$  = lag in hours  
 $\ell$  = hydraulic length of the watershed in feet  
 $s = \frac{1000}{CN} - 10$  where  $CN$  = hydrologic soil curve number  
 $Y$  = average watershed land slope in percent.

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \quad (\text{Equation 15-3})$$

where:  $T_c$  = time of concentration in hours  
 $L$  = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_c \quad (\text{Equation 16-12})$$

where:  $\Delta D$  = duration of unit excess rainfall  
 $T_c$  = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

- d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

- e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

- (1) 1 and 10 percent probability events - spillway crest elevation
- (2) Probable Maximum Storm - spillway crest elevation

- f. Spillway Rating Curve. The HEC-2 computer program was used to compute the spillway rating curve for each spillway using discharge channel cross sections and conveyance characteristics. The curves were then combined and entered on the Y4 and Y5 cards in the HEC-1 computer program.

## B.2 Pertinent Data

- a. Drainage area.  $0.48 \text{ mi}^2$
- b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.

- c. Lag time. 1.1 hrs
- d. Hydrologic soil group. C
- e. SCS curve numbers.
  - 1. For PMF- AMC III - Curve Number 86
  - 2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 71
- f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Berryman 7.5 minute quadrangle map. The data were entered on the \$A and \$E cards so that the HEC-1 program could compute storage volumes.
- g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the \$D, \$L, and \$V cards.
- h. Outflow capacity. The spillway rating curves were developed from the cross-section data of the main and auxiliary spillways and the downstream channels, using the HEC-2 backwater program. The results of the above were combined and entered on the Y4 and Y5 cards of the HEC-1 program.
- i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 1005.1 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 1005.1 ft, the spillway crest elevation.

### B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 and HEC-2 output are available in the project files.

PMF

\*\*\*\*\*  
 PLUDD HYDROGRAPH PACKAGE (HEC-1)  
 DAM 31256-VENTURON JULY 1978  
 LAST MODIFICATION 01 APR 80  
 \*\*\*\*\*

21 HENPECK HOLLOW DAM NO. 31256.  
 22 WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009  
 23 PROBABLE MAXIMUM FLOOD (PMF)

24	200	0	10	-0	-0	-0	-0	-0	-0
25	B1	5							
26	J	1	4	1					
27	J1	.25	.50	.75	1.0				
28	K	0	LAKE						1
29	K1	0	HENPECK HOLLOW LAKE INFLOW COMPUTATIONS						
30	M	1	2	3.8	1.0				
31	P	0	26.0	102.0	120.0	130.0	140.0		
32	T								
33	M2		1.1						.02
34	X	-1	-.05						
35	K	1	DAM						1
36	K1								
37	V								
38	V1	1							
39	V1005.1	1005.9	1006.0	1007.1	1008.0	1009.3	1009.5	1010.0	1010.3
40	V5	0.	16.0	40.0	130.0	260.0	380.0	520.0	640.0
41	V4	0.	2.7	9.0	8.4	4.2	20.2		
42	V1	987.0	1000.0	1005.1	1009.0	1010.0	1020.0		
43	V1005.1								
44	V1008.0	2.6	1.5						
45	V1	0.	72.0	137.0	152.0	176.0	182.0	292.0	402.0
46	V1008.0	1099.0	1099.2	1099.5	1010.0	1010.1	1010.3	1010.5	
47	K	99							

Input Data  
 Various PMF Events  
 Henpeck Hollow Dam  
 MO 31256  
 B4

\*\*\*\*\*  
 PLUMB HYDROGRAPH PACKAGE (HEC-1)  
 USER: JAMES W. WILSON JULY 14/80  
 LAST MODIFICATION 01 APR 80  
 \*\*\*\*\*

RUN DATE: 15 AUG 80  
 TIME: 05.44.30

HEMPECK HOLLOW DAM NO. 31256.  
 WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009  
 PROBABLE MAXIMUM FLOOD(PMF)

JOB SPECIFICATION									
NO	MNR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	0	0
JOPER 5									
				NWT	LROPT	TRACE			
				0	0	0			0

MULTI-PLAN ANALYSES TO BE PERFORMED  
 MPLAN= 1 RTIO= 1.00

RTIO= .25 .50 .75 1.00

SUB-AREA RUNOFF COMPUTATION

HEMPECK HOLLOW LAKE INFLOW COMPUTATIONS

ISTAG	ICOMP	IECON	ITAPE	JPLT	JPRY	ISAME	ISAGE	ISAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IMVDC	1UNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.48	0.	.46	1.00	0.	0	0	0

PRECIP DATA

SPEE	PHS	R6	R12	R24	R48	P72	R96
0.	26.00	102.00	120.00	130.00	140.00	0.	0.

LOSS DATA

LROPT	STAKR	DLIKR	RTIUL	ERAIN	STIRK	RTIOK	STPIL	CNSTL	ALSMX	RTIMP
0	0	0	1.00	0.	0.	1.00	-1.00	-86.00	0.	.02

CURVE NO = -86.00 WEIRNESS = -1.00 EFFECT CN = 86.00

UNIT HYDROGRAPH DATA

YC= 0. LAG= 1.10

REFLECTION DATA

STIRU= -1.00 ORCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 35 END UP PERIOD URDINATES, IC= 0. HOURS, LAG= 1.10 VOL= 1.00

Output Summary  
 Various PMF Events  
 Henpeck Hollow Dam  
 MO 31256  
 B5

# UNIT HYDROGRAPH DATA

TC= -0.0

LAG= 1.10

## RECESSION DATA

SINIO= -1.00 OKCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 35 END UP PERIOD ORIGINATES. TC= -0.0 HOURS. LAG= 1.10 VOL= 1.00  
 11. 34. 68. 116. 162. 187. 191. 173. 173. 19. 151.  
 12. 9. 7. 6. 5. 4. 3. 2. 2. 2.  
 1. 1. 1. 0. 0. 0. 0. 0. 0. 0.

## END-OF-PERIOD FLOW

0	NO.DA	MM.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	NO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	1.01	1.10	1	.00	.00	.00	0.	1.02	1.02	1.10	145	.03	.02	.00
1.01	1.01	1.20	2	.00	.00	.00	0.	1.02	1.02	1.20	146	.03	.02	.00
1.01	1.01	1.30	3	.00	.00	.00	0.	1.02	1.02	1.30	147	.03	.02	.00
1.01	1.01	1.40	4	.00	.00	.00	0.	1.02	1.02	1.40	148	.03	.02	.00
1.01	1.01	1.50	5	.00	.00	.00	0.	1.02	1.02	1.50	149	.03	.02	.00
1.01	1.01	2.00	6	.00	.00	.00	0.	1.02	1.02	2.00	150	.03	.02	.00
1.01	1.01	2.10	7	.00	.00	.00	0.	1.02	1.02	2.10	151	.03	.02	.00
1.01	1.01	2.20	8	.00	.00	.00	0.	1.02	1.02	2.20	152	.03	.02	.00
1.01	1.01	2.30	9	.00	.00	.00	0.	1.02	1.02	2.30	153	.03	.02	.00
1.01	1.01	2.40	10	.00	.00	.00	0.	1.02	1.02	2.40	154	.03	.02	.00
1.01	1.01	2.50	11	.00	.00	.00	0.	1.02	1.02	2.50	155	.03	.02	.00
1.01	1.01	3.00	12	.00	.00	.00	0.	1.02	1.02	3.00	156	.03	.02	.00
1.01	1.01	3.10	13	.00	.00	.00	0.	1.02	1.02	3.10	157	.03	.02	.00
1.01	1.01	3.20	14	.00	.00	.00	0.	1.02	1.02	3.20	158	.03	.02	.00
1.01	1.01	3.30	15	.00	.00	.00	0.	1.02	1.02	3.30	159	.03	.02	.00
1.01	1.01	3.40	16	.00	.00	.00	0.	1.02	1.02	3.40	160	.03	.02	.00
1.01	1.01	3.50	17	.00	.00	.00	0.	1.02	1.02	3.50	161	.03	.02	.00
1.01	1.01	4.00	18	.00	.00	.00	0.	1.02	1.02	4.00	162	.03	.02	.00
1.01	1.01	4.10	19	.00	.00	.00	0.	1.02	1.02	4.10	163	.03	.02	.00
1.01	1.01	4.20	20	.00	.00	.00	0.	1.02	1.02	4.20	164	.03	.02	.00
1.01	1.01	4.30	21	.00	.00	.00	0.	1.02	1.02	4.30	165	.03	.02	.00
1.01	1.01	4.40	22	.00	.00	.00	0.	1.02	1.02	4.40	166	.03	.02	.00
1.01	1.01	4.50	23	.00	.00	.00	0.	1.02	1.02	4.50	167	.03	.02	.00
1.01	1.01	5.00	24	.00	.00	.00	0.	1.02	1.02	5.00	168	.03	.02	.00
1.01	1.01	5.10	25	.00	.00	.00	0.	1.02	1.02	5.10	169	.03	.02	.00
1.01	1.01	5.20	26	.00	.00	.00	0.	1.02	1.02	5.20	170	.03	.02	.00
1.01	1.01	5.30	27	.00	.00	.00	0.	1.02	1.02	5.30	171	.03	.02	.00
1.01	1.01	5.40	28	.00	.00	.00	0.	1.02	1.02	5.40	172	.03	.02	.00
1.01	1.01	5.50	29	.00	.00	.00	0.	1.02	1.02	5.50	173	.03	.02	.00
1.01	1.01	6.00	30	.00	.00	.00	0.	1.02	1.02	6.00	174	.03	.02	.00
1.01	1.01	6.10	31	.00	.00	.00	0.	1.02	1.02	6.10	175	.03	.02	.00
1.01	1.01	6.20	32	.00	.00	.00	0.	1.02	1.02	6.20	176	.03	.02	.00
1.01	1.01	6.30	33	.00	.00	.00	0.	1.02	1.02	6.30	177	.03	.02	.00
1.01	1.01	6.40	34	.00	.00	.00	0.	1.02	1.02	6.40	178	.03	.02	.00
1.01	1.01	6.50	35	.00	.00	.00	0.	1.02	1.02	6.50	179	.03	.02	.00
1.01	1.01	7.00	36	.00	.00	.00	0.	1.02	1.02	7.00	180	.03	.02	.00
1.01	1.01	7.10	37	.01	.00	.01	0.	1.02	1.02	7.10	181	.13	.12	.01
1.01	1.01	7.20	38	.01	.00	.01	0.	1.02	1.02	7.20	182	.13	.12	.01
1.01	1.01	7.30	39	.01	.00	.01	0.	1.02	1.02	7.30	183	.13	.12	.01
1.01	1.01	7.40	40	.01	.00	.01	0.	1.02	1.02	7.40	184	.13	.12	.01
1.01	1.01	7.50	41	.01	.00	.01	0.	1.02	1.02	7.50	185	.13	.12	.01
1.01	1.01	8.00	42	.01	.00	.01	0.	1.02	1.02	8.00	186	.13	.12	.01
1.01	1.01	8.10	43	.01	.00	.01	0.	1.02	1.02	8.10	187	.13	.12	.01
1.01	1.01	8.20	44	.01	.00	.01	0.	1.02	1.02	8.20	188	.13	.12	.01
1.01	1.01	8.30	45	.01	.00	.01	0.	1.02	1.02	8.30	189	.13	.12	.01
1.01	1.01	8.40	46	.01	.00	.01	0.	1.02	1.02	8.40	190	.13	.12	.01
1.01	1.01	8.50	47	.01	.00	.01	0.	1.02	1.02	8.50	191	.13	.12	.01

Output Summary  
 Various PMF Events  
 Henpeck Hollow Dam  
 MO 31256

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Output Summary									
Various PMF Events									
Henpeck Hollow Dam									
MO 31256									
B7									
1.01	8.00	48	.01	.00	.01	.00	.01	.00	.01
1.01	8.10	49	.01	.00	.01	.00	.01	.00	.01
1.01	8.20	50	.01	.00	.01	.00	.01	.00	.01
1.01	8.30	51	.01	.00	.01	.00	.01	.00	.01
1.01	8.40	52	.01	.00	.01	.00	.01	.00	.01
1.01	8.50	53	.01	.00	.01	.00	.01	.00	.01
1.01	9.00	54	.01	.00	.01	.00	.01	.00	.01
1.01	9.10	55	.01	.00	.01	.00	.01	.00	.01
1.01	9.20	56	.01	.00	.01	.00	.01	.00	.01
1.01	9.30	57	.01	.00	.01	.00	.01	.00	.01
1.01	9.40	58	.01	.00	.01	.00	.01	.00	.01
1.01	9.50	59	.01	.00	.01	.00	.01	.00	.01
1.01	10.00	60	.01	.00	.01	.00	.01	.00	.01
1.01	10.10	61	.01	.00	.01	.00	.01	.00	.01
1.01	10.20	62	.01	.00	.01	.00	.01	.00	.01
1.01	10.30	63	.01	.00	.01	.00	.01	.00	.01
1.01	10.40	64	.01	.00	.01	.00	.01	.00	.01
1.01	10.50	65	.01	.00	.01	.00	.01	.00	.01
1.01	11.00	66	.01	.00	.01	.00	.01	.00	.01
1.01	11.10	67	.01	.00	.01	.00	.01	.00	.01
1.01	11.20	68	.01	.00	.01	.00	.01	.00	.01
1.01	11.30	69	.01	.00	.01	.00	.01	.00	.01
1.01	11.40	70	.01	.00	.01	.00	.01	.00	.01
1.01	11.50	71	.01	.00	.01	.00	.01	.00	.01
1.01	12.00	72	.01	.00	.01	.00	.01	.00	.01
1.01	12.10	73	.03	.01	.03	.01	.03	.01	.03
1.01	12.20	74	.03	.01	.03	.01	.03	.01	.03
1.01	12.30	75	.03	.01	.03	.01	.03	.01	.03
1.01	12.40	76	.03	.01	.03	.01	.03	.01	.03
1.01	12.50	77	.03	.01	.03	.01	.03	.01	.03
1.01	13.00	78	.03	.01	.03	.01	.03	.01	.03
1.01	13.10	79	.04	.01	.03	.01	.03	.01	.03
1.01	13.20	80	.04	.01	.03	.01	.03	.01	.03
1.01	13.30	81	.04	.02	.03	.02	.03	.02	.03
1.01	13.40	82	.04	.02	.03	.02	.03	.02	.03
1.01	13.50	83	.04	.02	.03	.02	.03	.02	.03
1.01	14.00	84	.04	.02	.03	.02	.03	.02	.03
1.01	14.10	85	.05	.03	.04	.03	.04	.03	.04
1.01	14.20	86	.05	.03	.04	.03	.04	.03	.04
1.01	14.30	87	.05	.03	.04	.03	.04	.03	.04
1.01	14.40	88	.05	.03	.04	.03	.04	.03	.04
1.01	14.50	89	.05	.03	.04	.03	.04	.03	.04
1.01	15.00	90	.05	.03	.04	.03	.04	.03	.04
1.01	15.10	91	.05	.03	.04	.03	.04	.03	.04
1.01	15.20	92	.08	.07	.07	.04	.07	.04	.07
1.01	15.30	93	.14	.09	.05	.04	.05	.04	.05
1.01	15.40	94	.35	.24	.11	.05	.11	.05	.11
1.01	15.50	95	.10	.07	.03	.03	.03	.03	.03
1.01	16.00	96	.00	.05	.02	.05	.02	.05	.02
1.01	16.10	97	.05	.04	.01	.04	.01	.04	.01
1.01	16.20	98	.05	.04	.01	.04	.01	.04	.01
1.01	16.30	99	.05	.04	.01	.04	.01	.04	.01
1.01	16.40	100	.05	.04	.01	.04	.01	.04	.01
1.01	16.50	101	.05	.04	.01	.04	.01	.04	.01
1.01	17.00	102	.05	.04	.01	.04	.01	.04	.01
1.01	17.10	103	.04	.03	.01	.03	.01	.03	.01
1.01	17.20	104	.04	.03	.01	.03	.01	.03	.01
1.01	17.30	105	.04	.03	.01	.03	.01	.03	.01
1.01	17.40	106	.04	.03	.01	.03	.01	.03	.01
1.01	17.50	107	.04	.03	.01	.03	.01	.03	.01
1.01	18.00	108	.04	.03	.01	.03	.01	.03	.01
1.01	18.10	109	.07	.00	.00	.00	.00	.00	.00
1.01	18.20	110	.00	.00	.00	.00	.00	.00	.00

Output Summary  
Various PMF Events  
Henpeck Hollow Dam  
MO 31256

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1.01	17.10	105	.04	.03	.01	.95	1.02	17.30	244	.49	.49	.00	1310.
1.01	17.40	106	.04	.03	.01	.98	1.02	17.40	250	.49	.49	.00	1312.
1.01	17.50	107	.04	.03	.01	.93	1.02	17.50	251	.49	.49	.00	1313.
1.01	18.00	108	.04	.03	.01	.78	1.02	18.00	252	.49	.49	.00	1314.
1.01	18.10	109	.07	.00	.00	.74	1.02	18.10	253	.04	.04	.00	1315.
1.01	18.20	110	.00	.00	.00	.64	1.02	18.20	254	.04	.04	.00	1316.
1.01	18.30	111	.00	.00	.00	.65	1.02	18.30	255	.04	.04	.00	1317.
1.01	18.40	112	.00	.00	.00	.54	1.02	18.40	256	.04	.04	.00	1318.
1.01	18.50	113	.00	.00	.00	.53	1.02	18.50	257	.04	.04	.00	1319.
1.01	19.00	114	.00	.00	.00	.46	1.02	19.00	258	.04	.04	.00	1320.
1.01	19.10	115	.00	.00	.00	.40	1.02	19.10	259	.04	.04	.00	1321.
1.01	19.20	116	.00	.00	.00	.33	1.02	19.20	260	.04	.04	.00	1322.
1.01	19.30	117	.00	.00	.00	.24	1.02	19.30	261	.04	.04	.00	1323.
1.01	19.40	118	.00	.00	.00	.23	1.02	19.40	262	.04	.04	.00	1324.
1.01	19.50	119	.00	.00	.00	.14	1.02	19.50	263	.04	.04	.00	1325.
1.01	20.00	120	.00	.00	.00	.16	1.02	20.00	264	.04	.04	.00	1326.
1.01	20.10	121	.00	.00	.00	.14	1.02	20.10	265	.04	.04	.00	1327.
1.01	20.20	122	.00	.00	.00	.12	1.02	20.20	266	.04	.04	.00	1328.
1.01	20.30	123	.00	.00	.00	.11	1.02	20.30	267	.04	.04	.00	1329.
1.01	20.40	124	.00	.00	.00	.10	1.02	20.40	268	.04	.04	.00	1330.
1.01	20.50	125	.00	.00	.00	.9	1.02	20.50	269	.04	.04	.00	1331.
1.01	21.00	126	.00	.00	.00	.7	1.02	21.00	270	.04	.04	.00	1332.
1.01	21.10	127	.00	.00	.00	.7	1.02	21.10	271	.04	.04	.00	1333.
1.01	21.20	128	.00	.00	.00	.7	1.02	21.20	272	.04	.04	.00	1334.
1.01	21.30	129	.00	.00	.00	.6	1.02	21.30	273	.04	.04	.00	1335.
1.01	21.40	130	.00	.00	.00	.6	1.02	21.40	274	.04	.04	.00	1336.
1.01	21.50	131	.00	.00	.00	.6	1.02	21.50	275	.04	.04	.00	1337.
1.01	22.00	132	.00	.00	.00	.6	1.02	22.00	276	.04	.04	.00	1338.
1.01	22.10	133	.00	.00	.00	.6	1.02	22.10	277	.04	.04	.00	1339.
1.01	22.20	134	.00	.00	.00	.5	1.02	22.20	278	.04	.04	.00	1340.
1.01	22.30	135	.00	.00	.00	.5	1.02	22.30	279	.04	.04	.00	1341.
1.01	22.40	136	.00	.00	.00	.5	1.02	22.40	280	.04	.04	.00	1342.
1.01	22.50	137	.00	.00	.00	.5	1.02	22.50	281	.04	.04	.00	1343.
1.01	23.00	138	.00	.00	.00	.5	1.02	23.00	282	.04	.04	.00	1344.
1.01	23.10	139	.00	.00	.00	.5	1.02	23.10	283	.04	.04	.00	1345.
1.01	23.20	140	.00	.00	.00	.5	1.02	23.20	284	.04	.04	.00	1346.
1.01	23.30	141	.00	.00	.00	.5	1.02	23.30	285	.04	.04	.00	1347.
1.01	23.40	142	.00	.00	.00	.5	1.02	23.40	286	.04	.04	.00	1348.
1.01	23.50	143	.00	.00	.00	.5	1.02	23.50	287	.04	.04	.00	1349.
1.02	0.	144	.00	.00	.00	.5	1.03	0.	288	.04	.04	.00	1350.
SUM									36.40	34.55	1.95	63510.	
									925.16	878.11	27.11	1392.401	

# PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

FLUWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)

AREA IN SQUARE MILES (SQUARE KILOMETERS)

## RATIOS APPLIED TO FLOWS

PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4  
 .25 .50 .75 1.00

STATION AREA PLAN RATIO 1 RATIO 2 RATIO 3 RATIO 4  
 LAK 1 584. 1174. 1768. 2357.  
 1.247 16.6911 33.3811 50.0711 66.7511

DAM 1 555. 1169. 1754. 2346.  
 1.247 15.7111 33.0911 49.6711 66.4411

## SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 INITIAL VALUE SPILLWAY CREST TOP OF DAM  
 ELEVATION 1005.10 1005.10 1008.90  
 STORAGE 33. 33. 60.  
 OUTFLOW 0. 0. 464.

RATIO MAXIMUM MAXIMUM MAXIMUM MAXIMUM MAXIMUM MAXIMUM  
 OF RESERVOIR DEPTH OVER DAM STORAGE AC-FT CFS CFS CFS  
 PMF W.S.ELEV OVER DAM  
 .25 1009.07 .27 62. 555. 1.17 41.00 0.  
 .50 1009.87 1.07 69. 1169. 4.00 40.83 0.  
 .75 1010.33 1.53 74. 1754. 5.50 40.83 0.  
 1.00 1010.66 1.86 77. 2346. 6.33 40.67 0.

Output Summary  
 Various PMF Events  
 Henpeck Hollow Dam  
 MO 31256

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS  
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)  
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

RATIO 1 RATIO 2 RATIO 3 RATIO 4

.20 .21 .22 .23

HYDROGRAPH AT LAKE .49 1 471. 495. 519. 542.  
 1.241 13.3511 14.0211 14.6911 15.3511

ROUTED TO DAM .49 1 434. 457. 481. 505.  
 1.241 12.3011 12.9511 13.6111 14.2911

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE SPILLWAY CREST TOP OF DAM  
 1005.10 1005.10 1008.40  
 STORAGE 33. 33. 60.  
 OUTFLOW 0. 0. 464.

RATIO OF PMF	MAXIMUM RESERVOIR ELEVATION	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	1008.69	0.	59.	434.	0.	41.00	0.
.21	1008.78	0.	60.	457.	0.	41.00	0.
.22	1008.86	.06	60.	481.	.50	41.00	0.
.23	1008.94	.14	61.	505.	.83	41.00	0.

Output Summary  
 Various PMF Events  
 Henpeck Hollow Dam  
 MO 31256

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**DATE**  
**ILME**